Missouri Department of Natural Resources

Wastewater Treatment Options for Small Communities

Water Protection Program fact sheet 7/2007

Currently, when many small communities are looking to upgrade their sewage treatment facility, they are faced with a daunting task of determining the best option for them. The option with the lowest construction cost is not always the best alternative for a community. Because small communities have a small customer base, they are limited in how much revenue they can generate with monthly sewer bills. New technologies can help with better and more efficient ways of treating sewage but communities need to evaluate all factors that affect costs, including construction cost, labor costs, energy, equipment replacement and land costs.

This fact sheet provides three categories of alternatives that should be considered for small communities with populations from 100 to 1,000. It emphasizes low technology alternatives that can be operated with minimal expertise and few hours of labor. Many of these alternatives are potentially applicable to larger cities but should be chosen based upon a complete economic analysis, which includes capital costs and annual operation and maintenance costs.

Natural Systems

The first category of treatment is natural systems such as lagoons and wetlands. Lagoons and wetlands are pond-like bodies of water or basins designed to receive, hold and treat wastewater for a set period of time. This can vary from a few weeks to three months. In the natural systems, wastewater is treated through a combination of physical, biological and chemical processes. Most of the treatment occurs naturally, but some systems use aeration devices to add oxygen to the wastewater.

Enhanced Natural Systems and Biological Filters

The second category of treatment is enhanced natural systems and filters. These systems and filters include a variety of systems that can be considered simple and easy to operate and ideal for small communities. Enhanced natural systems include technologies or a combination of technologies to overcome the treatment limitations associated with lagoons and wetlands. The two most significant treatment limitations are the growth of algae in ponds and the inability of natural systems to remove ammonia. In order to have high quality effluent, the algae in the ponds must be reduced to very low levels before it can be discharged. Two pounds of algae in a pond can become one pound of Biochemical Oxygen Demand (BOD) in the receiving stream. Ammonia must be reduced as well because high ammonia levels can be toxic to fish.

Biological filters are not necessarily related to natural systems but are included in this category because of its simplicity and operation.

Activated Sludge

The final group of treatment options is activated sludge processes. Large cities typically use this process. The activated sludge process is usually the most efficient choice for larger communities where it is possible to have full-time operators and an on-site laboratory for operational testing.

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There are times, however, when a small community will need to use the activated sludge process to meet the required effluent quality to protect the area streams. During the biological process, waste eating bacteria grow in an aeration tank. The bacteria clumps together and settles to the bottom of the settling tank and forms sludge. Clean water, which is suitable for discharge, is allowed to exit the top of the tank. Since this process will grow excess bacteria, a wastewater operator must pay careful attention to removing the bacteria sludge at proper intervals so that only clean water will be discharged. A fairly high degree of operational knowledge and skill is required to make sure organisms harmful to the process are not growing in the aeration tank and excess sludge is treated and disposed of safely.

Small Community Treatment System Options Table Explanation

The Small Community Treatment System Options table follows this detailed explanation of each rating and column. The table explains and rates several alternatives for each category of technology alternatives based on treatment efficiency, energy use, operational complexity and land required.

Treatment Efficiency

Treatment efficiency has ratings of Low, Medium and High. These relative ratings are based on general observations and literature concerning the typical effluent quality attainable from these technologies. A treatment efficiency rating of Low does not mean that the technology cannot effectively treat sewage. It just means that as compared to other alternatives it has the lowest efficiency. The treatment efficiencies or capabilities are described as follows:

- **Low:** Process is capable of meeting secondary treatment effluent limits (30 mg/l BOD, 30 mg/l TSS) or equivalent to secondary treatment limits (45 mg/l BOD, 70 mg/l TSS).
- **Medium:** Process is capable of meeting secondary treatment effluent limits (30 mg/l BOD, 30 mg/l TSS) and Total Ammonia Nitrogen limits of 2 mg/l.
- **High:** Process is capable of meeting advanced secondary treatment limits (10 mg/l BOD, 15 mg/l TSS) and Total Ammonia Nitrogen of 2 mg/l or less.

Energy Use

The lowest energy usage or Excellent rating is for lagoons and wetlands that do not use any electrical energy other than minimal amounts for pumping. The highest energy usage or Poor rating is when significant amounts of energy are required to mix and aerate large volumes of water in aerated lagoons.

Operational Complexity

Operational complexity ratings are based on the relative amount of time that an operator's time is required at the treatment facility and the level of licensing requirements for the operator. This rating also accounts for operational maintenance including equipment replacement. The ratings are completely described as follows:

- **Poor:** Processes that require an operator's attention from 20 to 40 hours per week and a "B" operator's license may be needed. Also factored into this rating is the operator must perform extensive operational testing and the monthly sewer bill must generate income to replace equipment as needed. This low rating is only for small communities that cannot generate the necessary income through its monthly sewer bills to fund extensive operational costs. For larger communities with a larger customer base and ability to fund monthly expenses, this lower rating would not be appropriate for these highly mechanical processes.

- **Fair to Good:** Technologies that may require more operational expertise than simple technologies and may require an operator with a "C" license. This rating would apply to technologies that require more expertise and experience than the simple natural systems do but less than a totally mechanical plant. An operator's attention would be required from 15 to 25 hours per week and equipment replacement costs could be substantial.
- **Excellent:** Natural systems, such as lagoons and wetlands or other simple processes, where an operator only has to perform a daily check to make sure that pumps and aeration devices are running properly. These processes usually only require an operator with a "D" license. The operator's services are usually only needed less than an hour or two each day and require only minimal operational expertise or testing.

Land Required

Land required rates the area required for different processes. Because land can be expensive or may not be available for sewage treatment in certain communities, communities must consider how much land may be required before seriously evaluating certain technologies. These ratings are based on constructing a new system. These rating would not apply to lagoon systems that already exist and a community is proposing to add treatment components. Depending on the topography, more land may be required than indicated below for a treatment facility to fit. Below is a description of the ratings:

- **Poor:** Requires approximately two acres of land area for every 100 people for simple lagoon systems. Add on processes such as overland flow, sand filters or wetlands can require up to 50 percent more land. Spray irrigation of the effluent can require up to 10 times more land than what is required for a lagoon system.
- **Fair to Good:** Systems such as aerated lagoons or recirculating pea gravel filters that require considerably less land than simple lagoon system but much more land than a mechanical plant. Typically, these systems require five acres or less for flows up to 100,000 gpd.
- **Excellent:** These systems are usually mechanical systems where the plant is manufactured in a factory and shipped to the treatment plant site. In most cases, an acre of land or less is required for flows of 100,000 gpd or less. Mechanical systems may be attractive in areas where land is very expensive or in hilly areas.

The list includes technologies at different stages of development or may lack extensive experience in Missouri. It is important to note that the department's regulations on new technology for sewage treatment allows the department to approve developing technologies where pilot plant testing has been conducted. It is very important that community leaders evaluate how much risk they are willing to take when considering new and developing technologies. To aid community leaders and engineers in evaluating various technologies and the associated risk the following definitions are recommended:

- Developing Technologies—Technologies that are currently undergoing pilot scale and field application testing are still considered as experimental or developing technologies.
- New Technology—Technology that has been extensively tested at the pilot-scale and is either on the threshold or already being applied in the field for full scale
- Proven technology—Technology that has an established performance record which usually means three separate installations operating at or near design capacity for three years and having performed consistently as designed without major failure of the process, unit or equipment. Three installations do not have to be located in Missouri but can be anywhere in the United States or Canada.

SMALL COMMUNITY TREATMENT SYSTEM OPTIONS

Treatment System	Treatment Efficiency	Energy Use	Operational Complexity	Land Required
1. NATURAL TREATMENT SYSTEMS				
Facultative Multi-Celled Lagoon (3 Cell flow through lagoon system)	Low	Excellent	Excellent	Poor
Aerated Lagoon (Aerated 2 or 3 cell lagoon system)	Low	Fair	Good - - Excellent	Fair
Facultative Lagoon/Wetland	Low	Excellent	Excellent	Poor
Slow Rate Irrigation (<5ft/yr) (Large lagoon storage systems with 90+ days of winter time storage and surface irrigation of the effluent for a No-Discharge system)	High	Good - Excellent	Good - Excellent	Poor
2. ENHANCED NATURAL SYSTEMS AND FILTERS				
Recirculating Pea Gravel Filter (5.0 gpd/ sq ft with recirculation tank and large septic tanks. Ranking criteria would also apply to the Tennessee Valley Authority (TVA) reciprocating wetland treatment system)	High	Excellent	Good - Excellent	Good
Controlled Discharge Lagoon (Evaluation criteria is based on data from Iowa)	Medium	Excellent	Good - Excellent	Poor
Aerated Lagoon with Proprietary Enhancements (Processes include complete and partial mix aeration basins and proprietary equipment such as floating covers, nitrification reactors and internal clarifiers)	High	Poor - Good	Good	Fair
Submerged Media Filters (Submerged filters utilizing media similar to trickling filters with low organic loading rates of 30# BOD/1,000 ft^3 or less.)	Medium	Good	Good	Excellent
Lagoon or Wetland Followed by Overland Flow (When overland flow follows a lagoon, additional steps may be needed to remove algae to meet an effluent TSS limit of 30 mg/l.)	Medium	Excellent	Good - Excellent	Poor
Artificial Media Filters (Textiles, Foam Rubber, Fibers,etc) (Manufacture representatives should be contacted for performance data, costs and sizing criteria.)	Medium	Excellent	Good	Good - Excellent
Lagoon or Wetland Followed by Sand Filter (New technology for Missouri, suggest using design criteria from other states or Canada where the technology has been fully proven.)	High	Excellent	Fair - Good	Poor
Drip Irrigation (10/15 Type Pretreatment) (Treatment Facility required to produce clean effluent and soil loading rates take into consideration the linear loading rate. New technology to Missouri for large scale systems.)	High	Fair	Fair	Poor
3. ACTIVATED SLUDGE				
Extended Aeration Package Plant (24 hour detention time with sludge digestion and storage. Sludge hauling or application and laboratory availability for operational testing must be evaluated)	Medium	Fair	Poor	Excellent
Biological Nutrient Removal (Very similar to package plant but much more operational expertise is required along with more operational testing.)	High	Fair	Poor	Excellent
Membrane Bioreactor (Excellent treatment results but community must be carefully evaluated for ability to pay for operation and annual costs which includes expensive membrane replacement.)	Very High	Poor -Fair	Poor	Excellent

NOTE: The above list is for discussion purposes only and should not in any way be construed as being regulatory or to be used by the department to approve or disapprove a particular process and design. The probable effluent limits achievable by the listed processes may be different for different designs and the probability of the facility receiving adequate operation and maintenance.

For more information

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